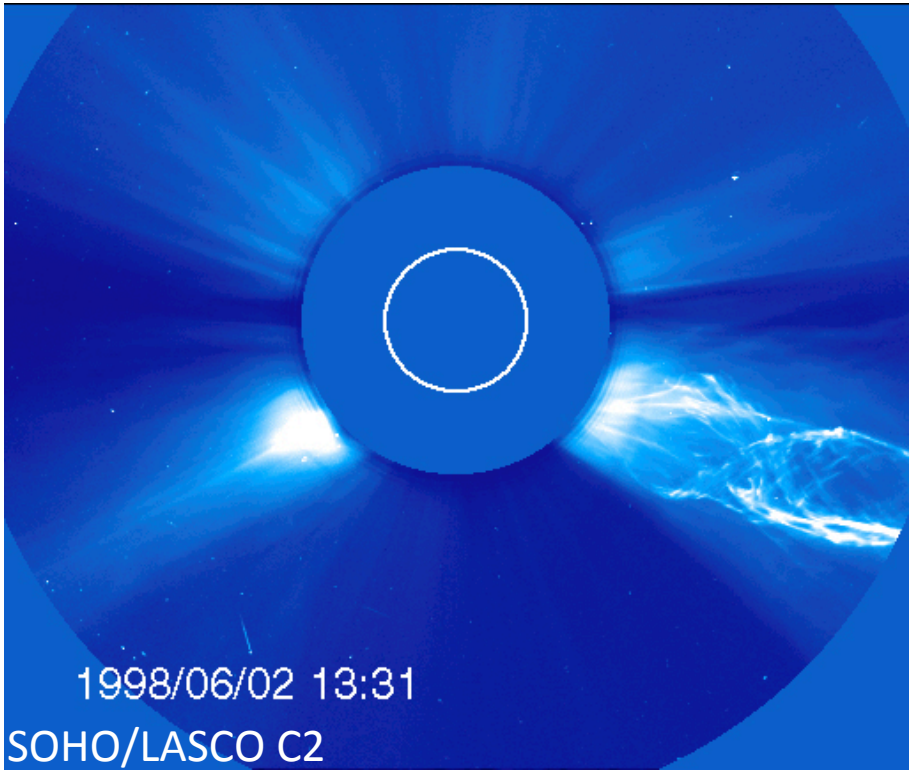
CME Analysis with SWPC_CAT for Space Weather



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SW REDI

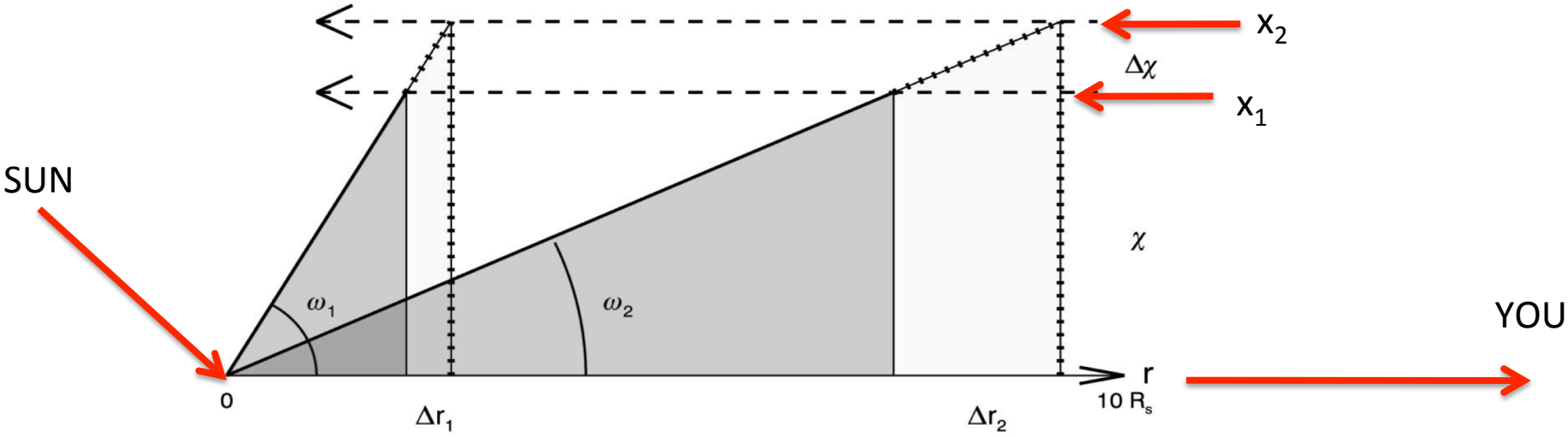
Geometric Triangulation

- StereoCAT assumes you are measuring the **same feature** in two coronagraphs. It uses simple geometric relations to derive CME position and speed.
- Unfortunately, the wider a CME is, the less likely it is that you're measuring the same feature. The leading edge from one viewpoint can be far away from the leading edge as seen from another viewpoint.
- Another problem: faster CMEs tend to be wider, so StereoCAT becomes less applicable for fast CMEs.

StereoCAT will always give you an answer, but you need to examine your results to determine whether you have a reasonable answer.

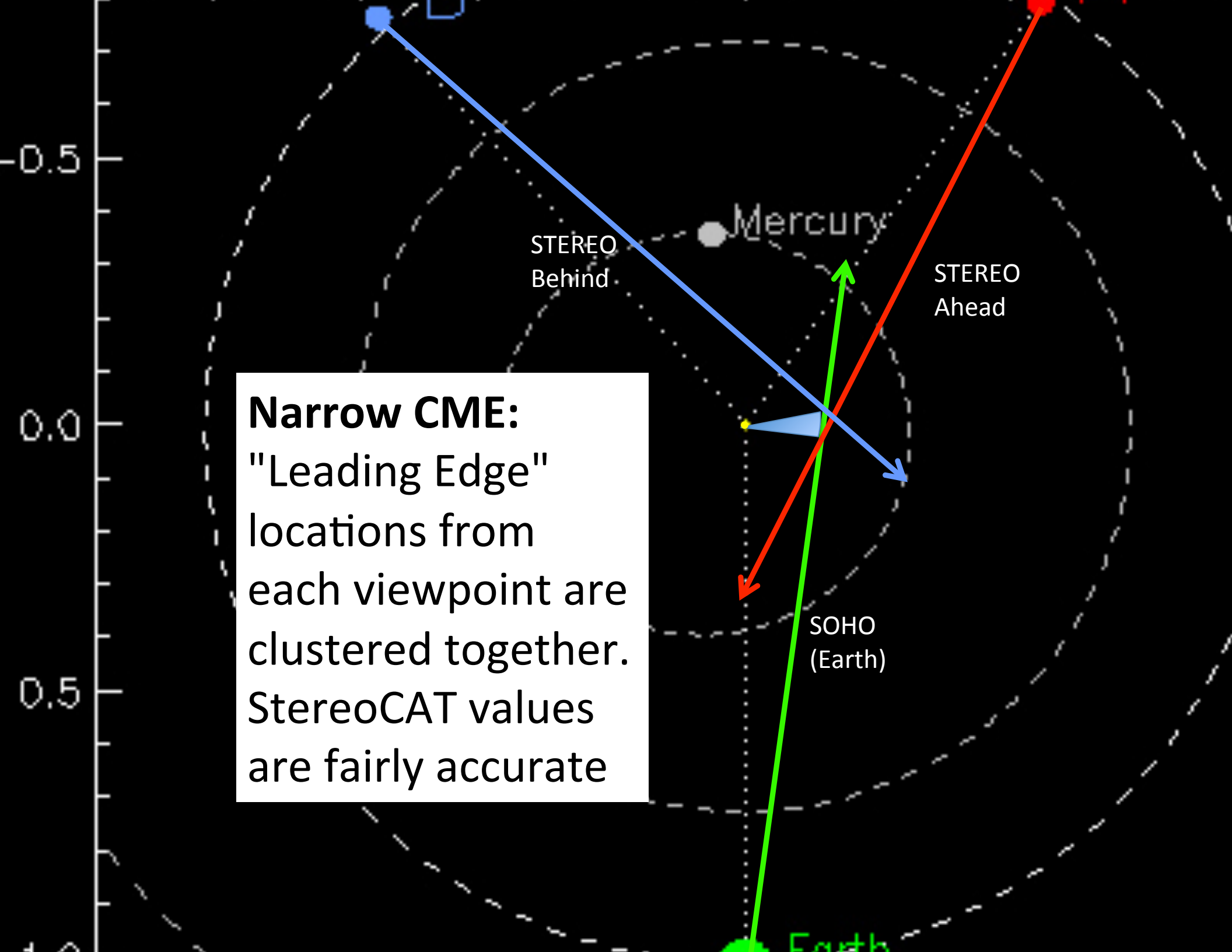
Geometric Triangulation

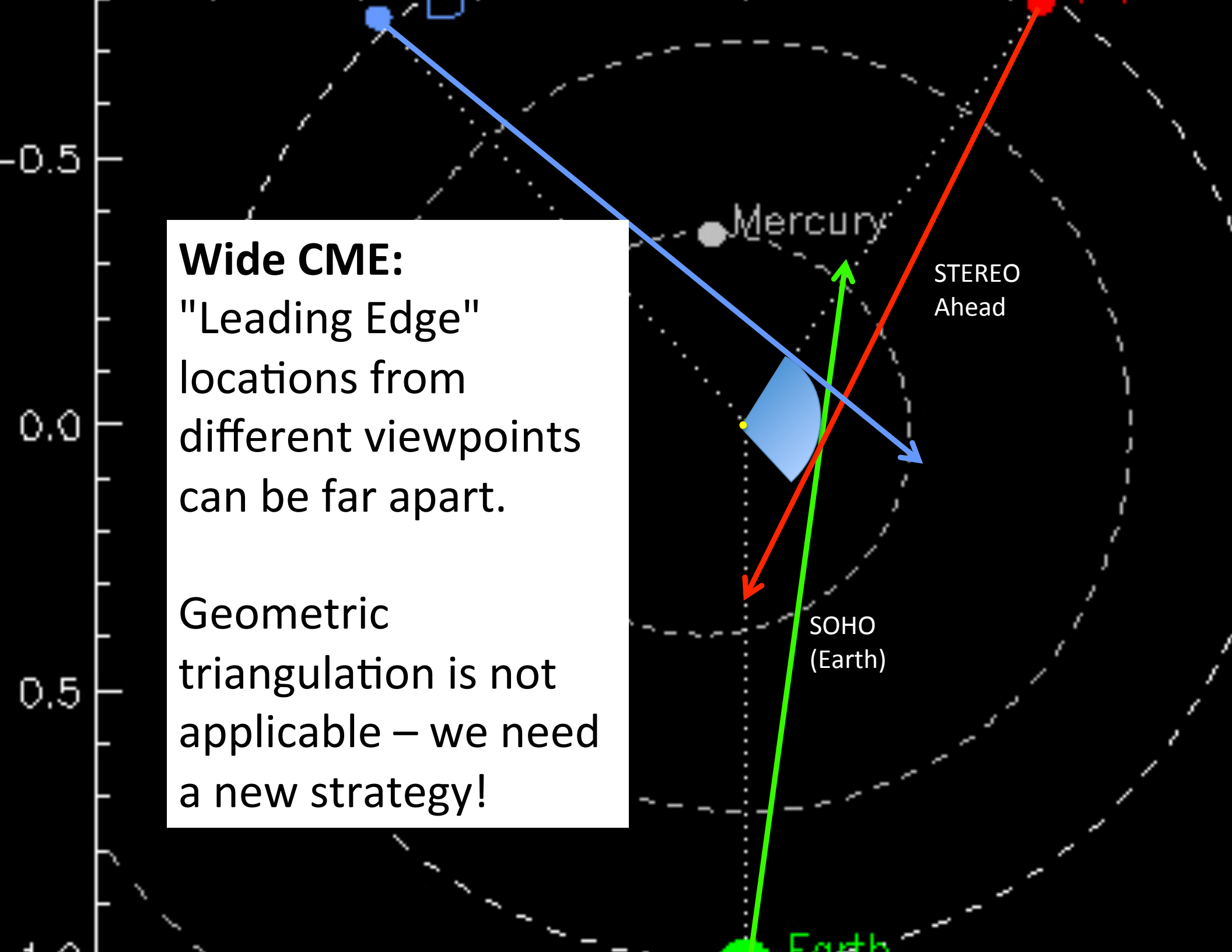
The "cone half-angle/radial distance conundrum"



Millward et al., 2013

When you see a halo CME, you are seeing the sides of the CME and not the leading edge. The left CME in the diagram is fast and wide, while the right CME is slower and narrower. However, the observer ("You") will measure the same change in distance (x_1 and x_2) and derive the same plane-of-sky speeds. To determine the 3D speed, you to know the width (which is unknown).


-0.5
0.0
0.5
Mercury
STEREO
Behind
STEREO
Ahead
SOHO
(Earth)
Earth
Narrow CME:
"Leading Edge"
locations from
each viewpoint are
clustered together.
StereoCAT values
are fairly accurate

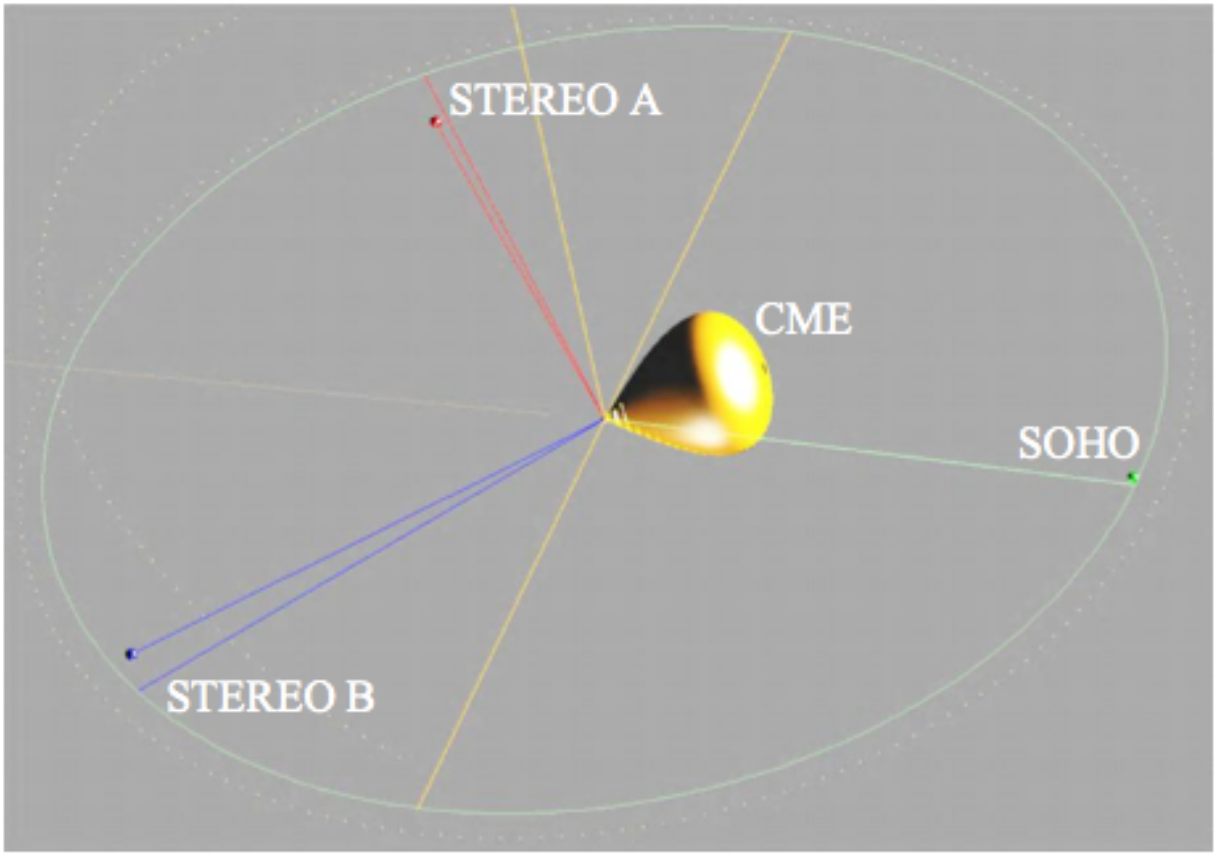


Wide CME:
"Leading Edge" locations from different viewpoints can be far apart.

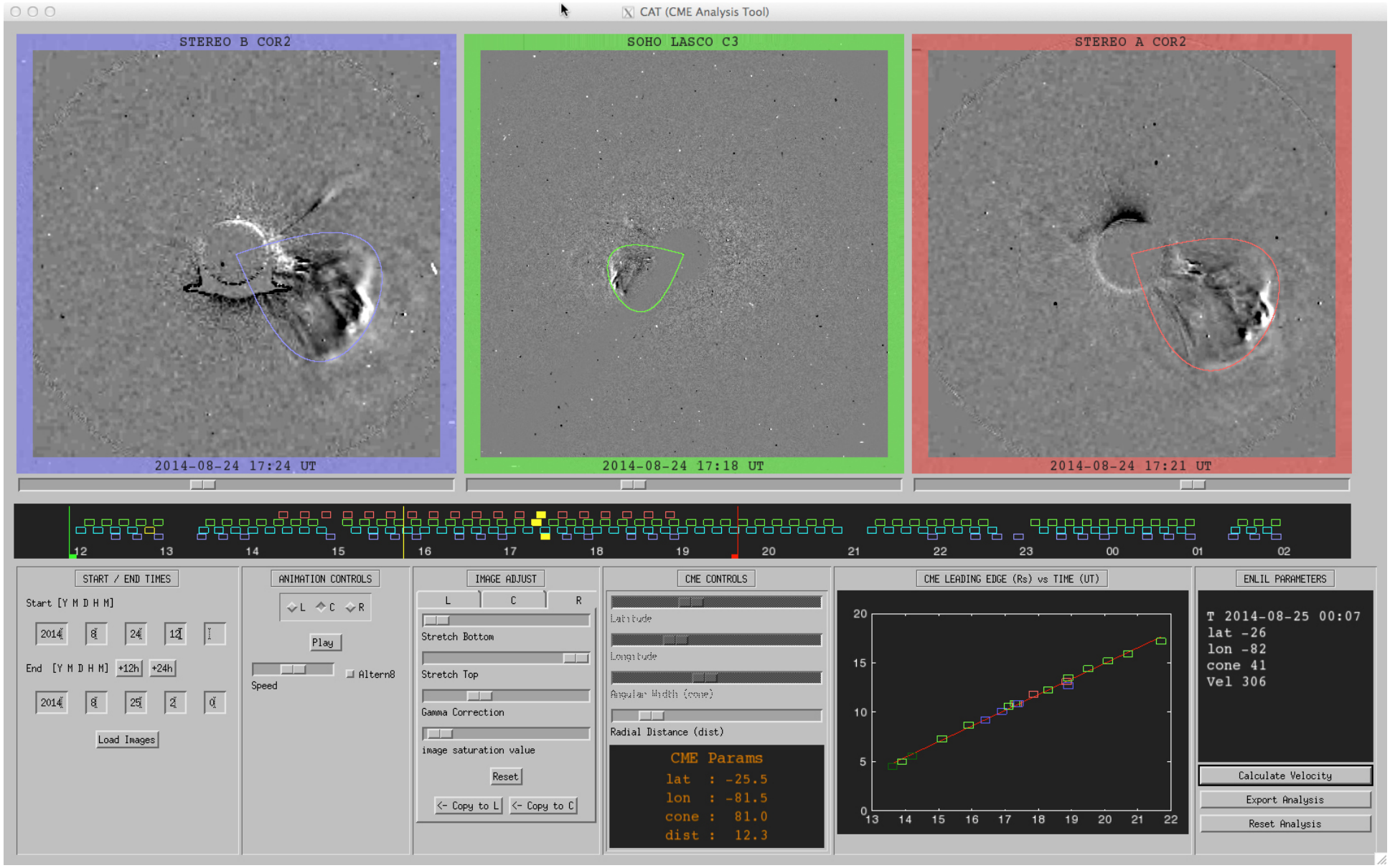
Geometric triangulation is not applicable – we need a new strategy!

How do we fix this??

We can use a model of a 3D CME shape and project that model from the different viewing angles. The easiest version of this is SWPC_CAT.



SWPC_CAT


CAT (CME Analysis Tool)
STEREO B COR2
2014-08-24 17:24 UT
SOHO LASCO C3
2014-08-24 17:18 UT
STEREO A COR2
2014-08-24 17:21 UT
12
13
14
15
16
17
18
19
20
21
22
23
00
01
02
START / END TIMES
Start [Y M D H M]
2014
8
24
12
1
End [Y M D H M]
+12h
+24h
2014
8
25
2
0
Load Images
ANIMATION CONTROLS
L
C
R
Play
Speed
Altern8
IMAGE ADJUST
L
C
R
Stretch Bottom
Stretch Top
Gamma Correction
image saturation value
Reset
<- Copy to L
<- Copy to C
CME CONTROLS
Latitude
Longitude
Angular Width (cone)
Radial Distance (dist)
CME Params
lat : -25.5
lon : -81.5
cone : 81.0
dist : 12.3
CME LEADING EDGE (Rs) vs TIME (UT)
20
15
10
5
0
13
14
15
16
17
18
19
20
21
22
ENLIL PARAMETERS
T 2014-08-25 00:07
lat -26
lon -82
cone 41
Vel 306
Calculate Velocity
Export Analysis
Reset Analysis

SWPCCat CME analysis Procedure

* Identify the CME and the start time. (First appearance)
* Look at EUV images in motion near the CME start time and identify the source location and any lower coronal signatures (post eruption arcade, dimming, rising loops, filament eruption).
* Figure out what "right click" is on your computer. You'll need it!
* Start sswidl (at the command prompt)

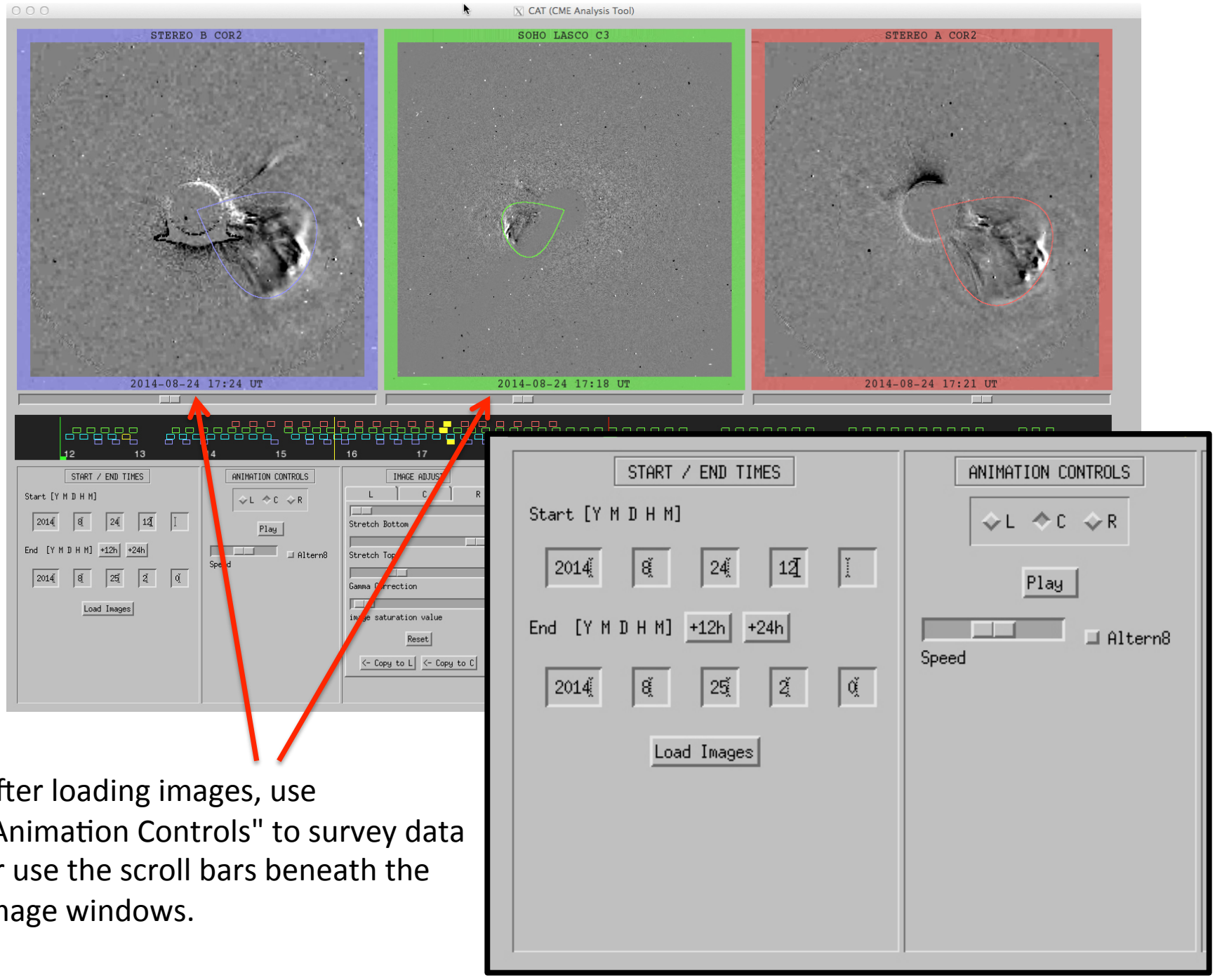
  $ sswidl
* Load images by typing the following commands at the IDL prompt:

  IDL> swpc_cat_getdata ; loads the past 24 hours of images

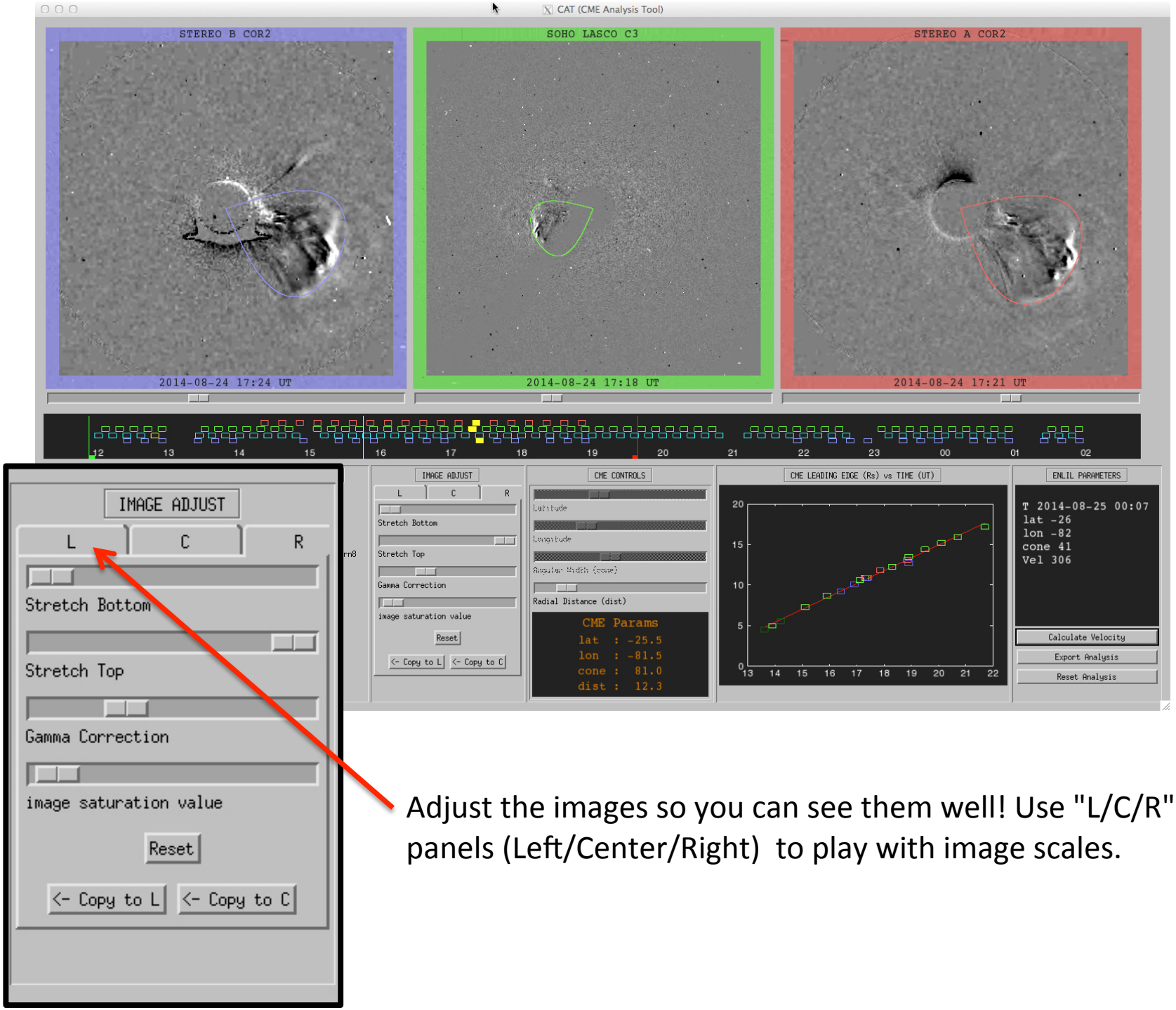
  -or choose a date range-

  IDL> swpc_cat_getdata, '2014-06-24 01:00','2014-06-24 18:00'
* Start SWPC_CAT by typing "swpc_cat" at the IDL prompt

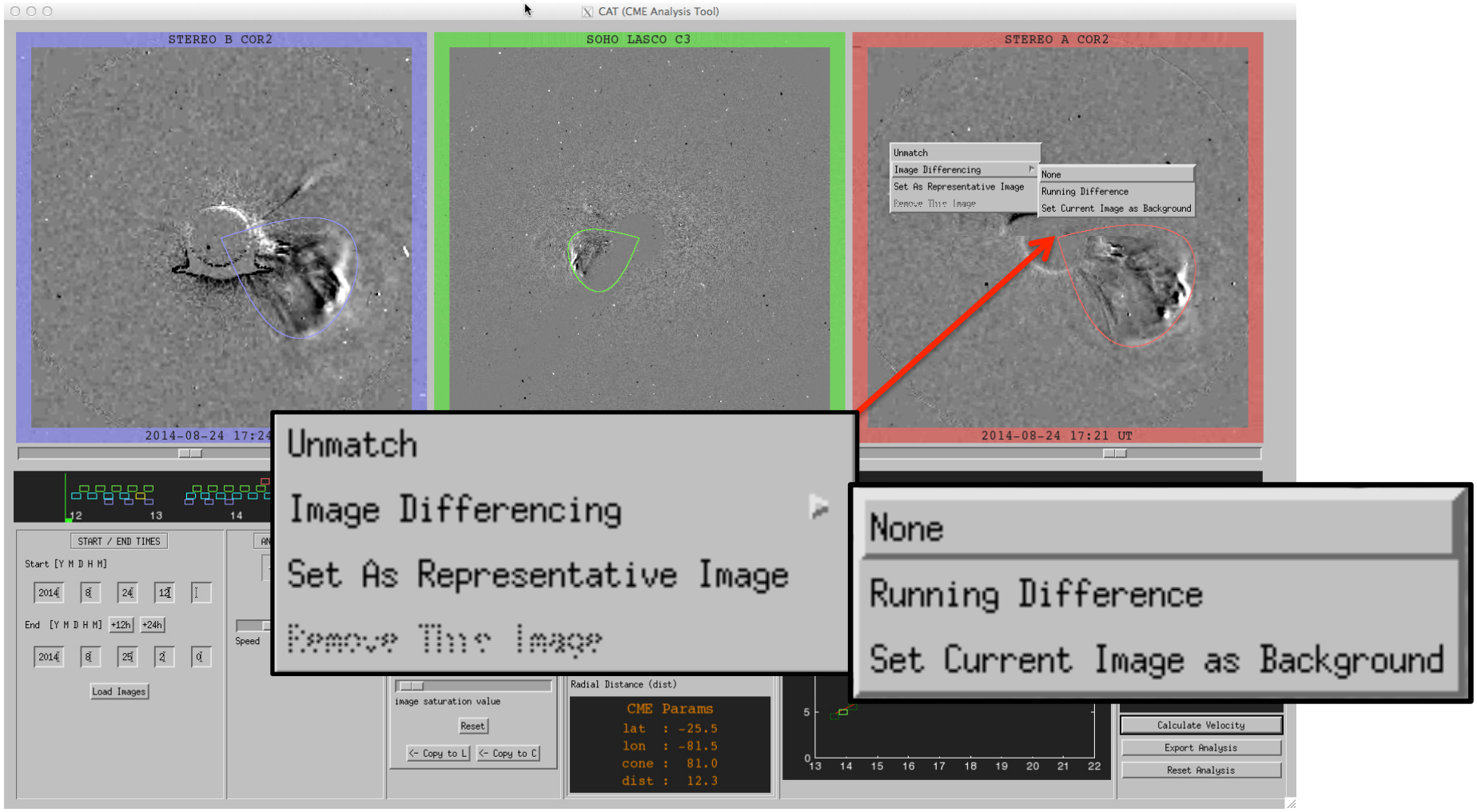
  IDL> swpc_cat
* Load the images: enter the start and end times in the lower left corner, and press "Load Images" button. Pick a start time that is ~ 1 hour before the CME start.
* The first thing you should do is survey the images: use the scroll bars below the image windows, or use the "Animation Controls" section to run the movies. You want to be sure they loaded properly and cover the entire range of images (from before LASCO C2 out to the edge of LASCO C3).



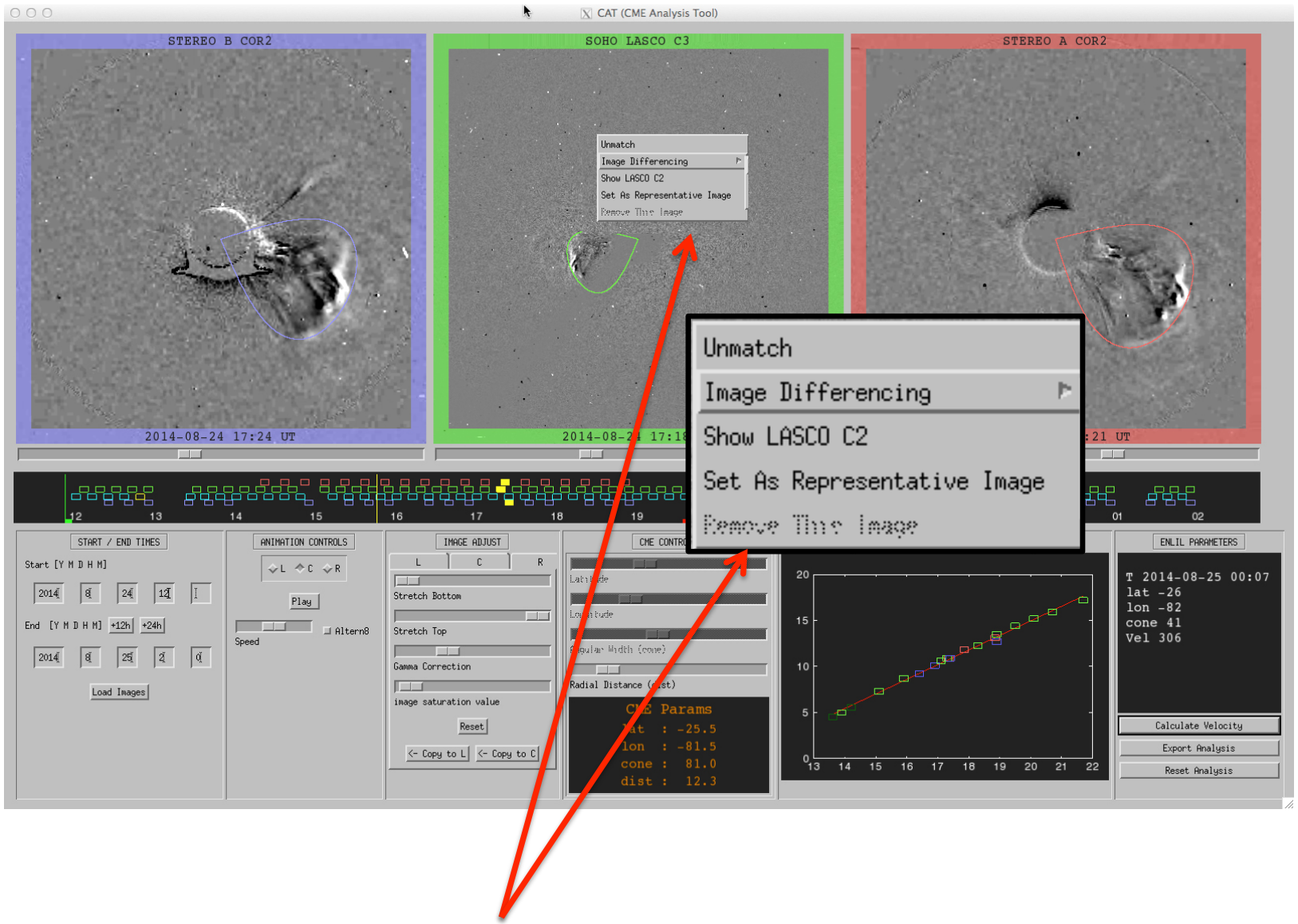
After loading images, use "Animation Controls" to survey data or use the scroll bars beneath the image windows.



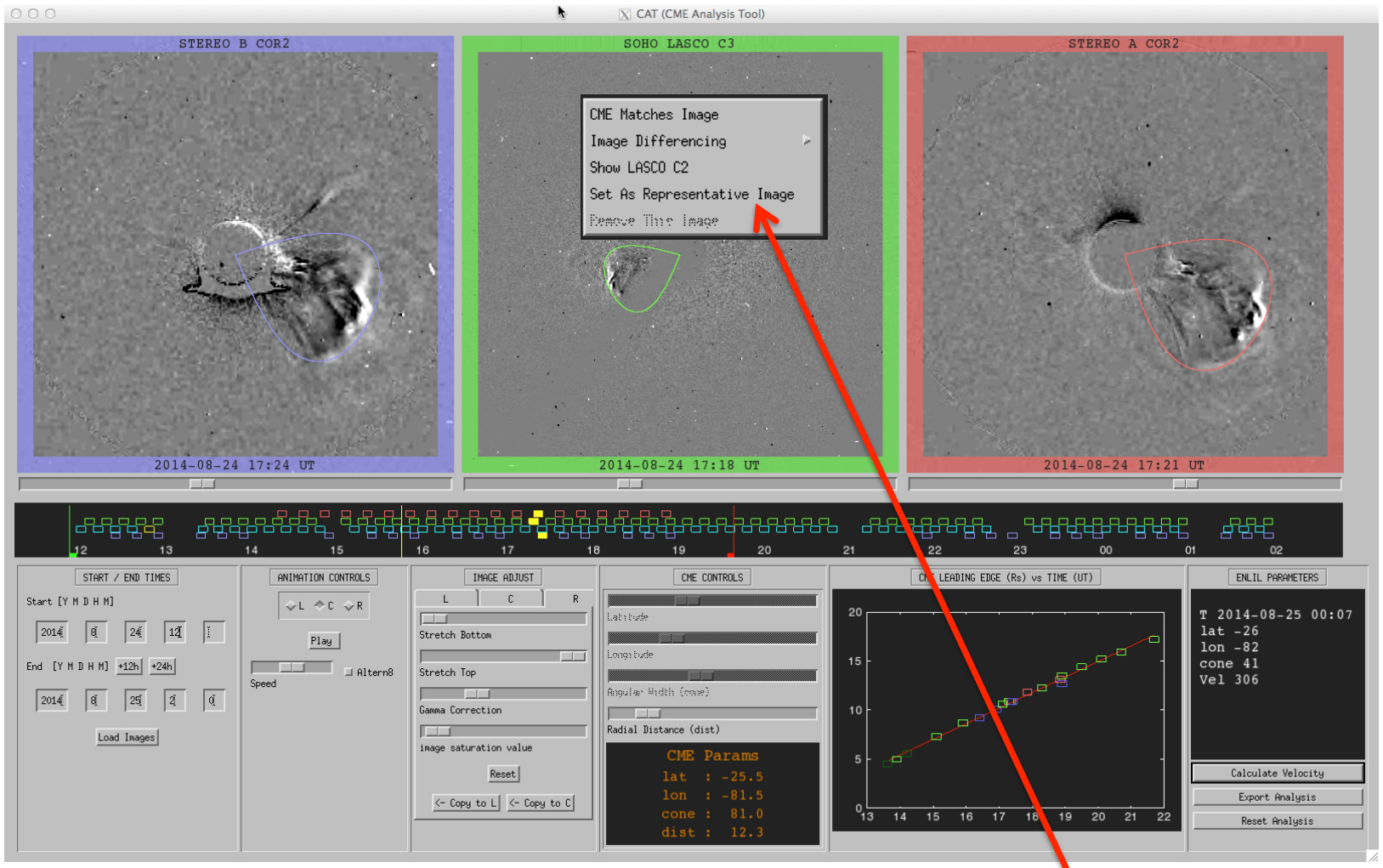
Adjust the images so you can see them well! Use "L/C/R" panels (Left/Center/Right) to play with image scales.



Another option is to adjust the way the images are displayed. Right click in one of the image panes, and then click on "Image Differencing." Your three options are "None" (display raw images; not recommended), "Running Difference" (probably the best) and "Set Current Image as Background" (i.e. pick an image time as your background that is before the time of your CME – this is useful if the Running Difference images are very busy)

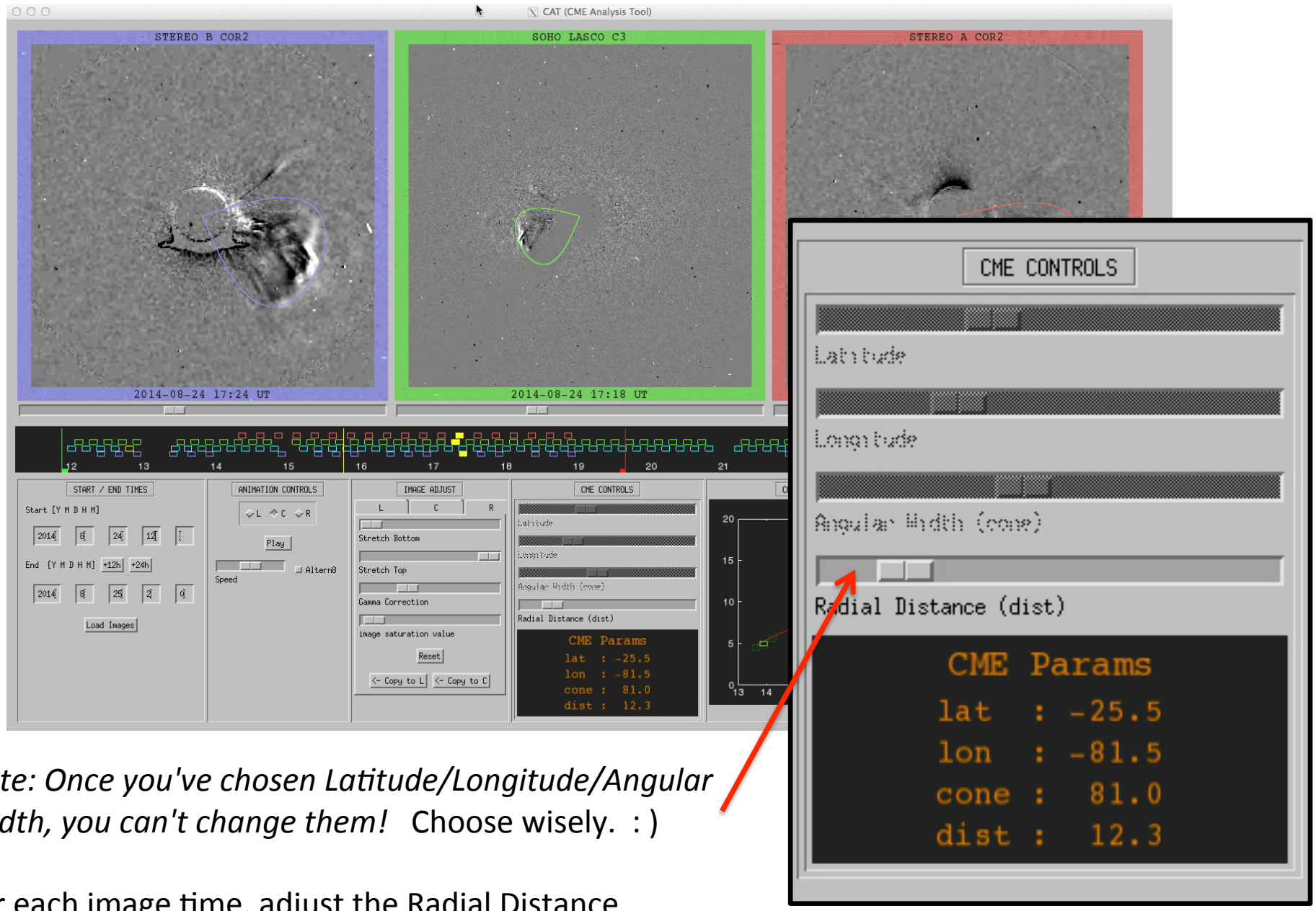


You can switch between the LASCO C2 and LASCO C3 images by right clicking in the middle image frame (SOHO) and selecting "Show LASCO C2" or "Show LASCO C3"



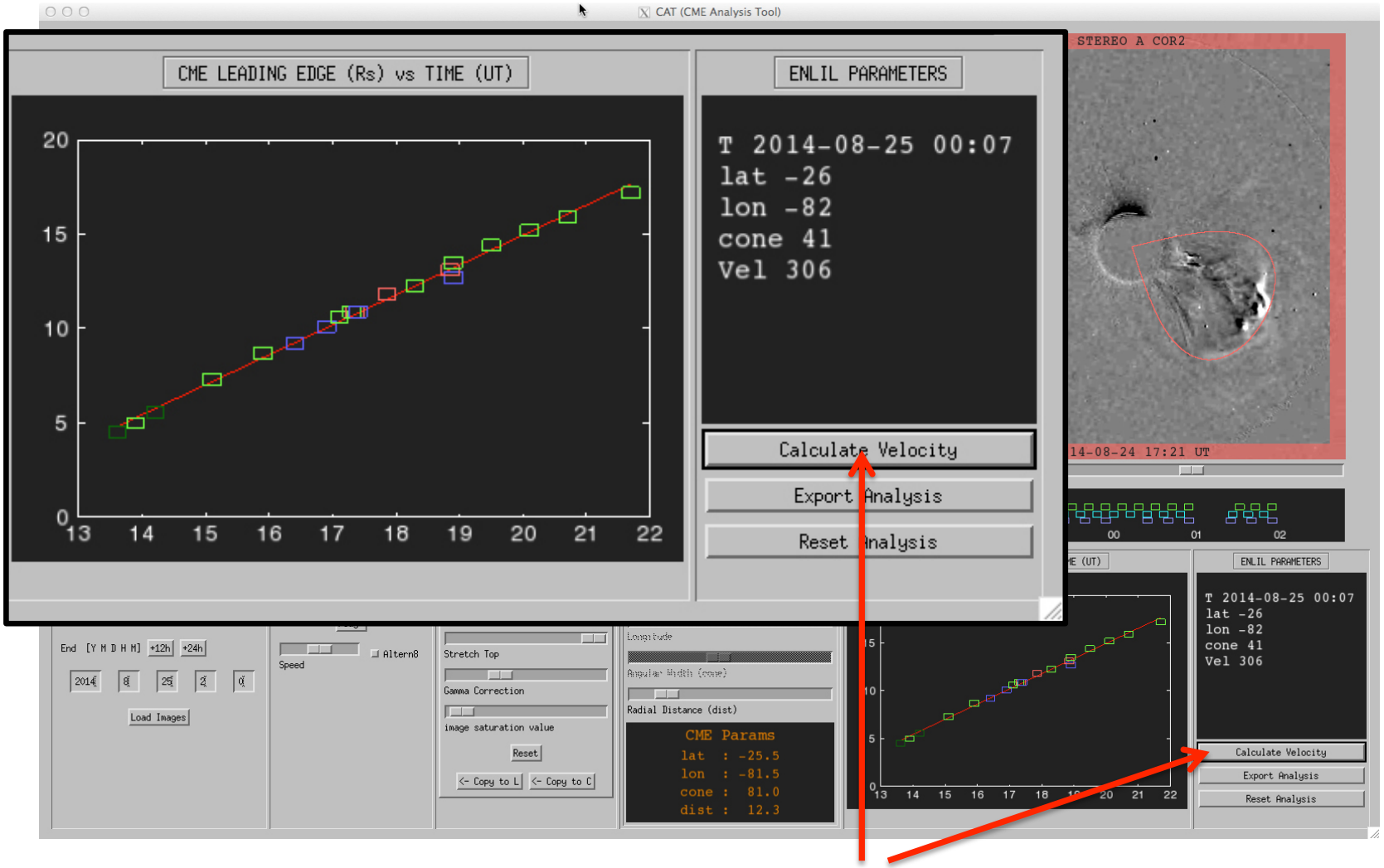
Choose a time where you can see the CME well, but also be sure that the CME's width & location isn't varying too rapidly. You're trying to determine the values corresponding to 21.5 RSun (but keep in mind that the earlier images may correspond better with the EUV images).

Experiment with the parameters and do your best to fit all three viewpoints. Once you think you've got good parameters, go into an image pane and click "CME Matches Image."

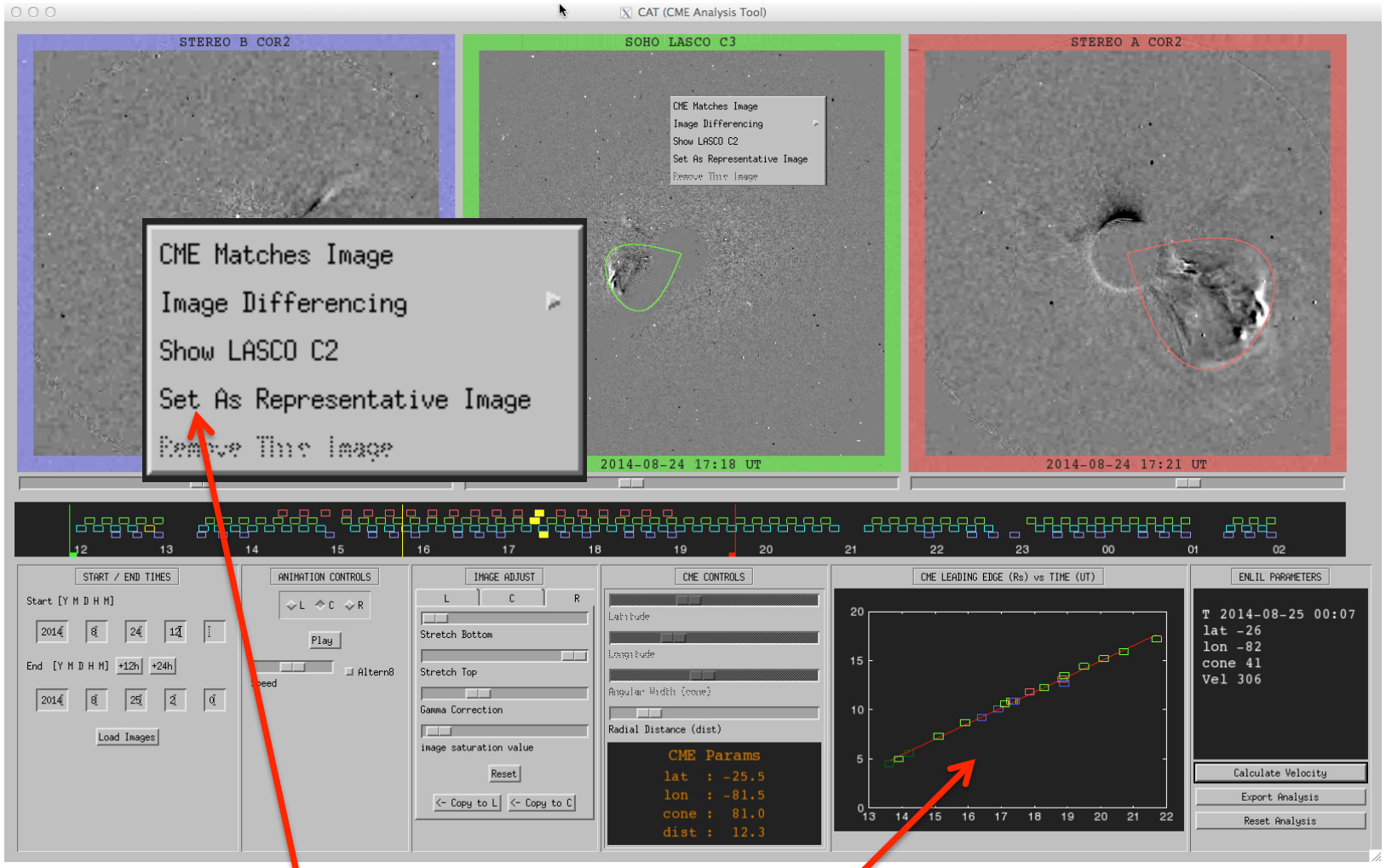


Note: Once you've chosen Latitude/Longitude/Angular Width, you can't change them! Choose wisely. :)

For each image time, adjust the Radial Distance slider until you think it matches closely. Note that image times do not have to match! Adjust the distance for each image time and select "Match Image."



Every time you click "CME Matches Image" you should see a small box outline appear in the "CME LEADING EDGE vs TIME" plot. Clicking "Calculate Velocity" will draw a line fit to the data points and then update the values in the "ENLIL PARAMETERS" box.



Finally, examine your values – if the speed looks roughly constant, you can use the derived values. If it looks like it is decelerating or accelerating, you may want to "Unmatch" some earlier images to make sure the velocity fit is only using later images (closer to 21.5 RSun).

To finish up: Pick a single image to serve as a "Representative Image" and select "Export Analysis." The final step is doing a screenshot of the whole thing (don't forget!)